NESTING HABITS OF SOME ANTHIDIINE BEES.

CLARENCE P. CUSTER AND CHARLES H. HICKS.

The habits of the Anthidiine bees have been studied by Fabre (2), Friese (3), Davidson (1), Melander (7), Newberry (8), Hungerford and Williams (6), Hicks (5), and others. Fabre early considered the genus *Anthidium* to consist of two groups, divided primarily on habits. One he termed "cotton-workers"; the other "resin-workers." The former now comprise the genus *Anthidium;* the latter *Dianthidium.* The habits of these bees have not been studied so thoroughly in America as in Europe. Studies of *Anthidium porteræ* Ckll. have been made by Hungerford and Williams (6) and Hicks (5), and *Dianthidium sayi* Ckll. by Hicks (5).

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We continued a study of these bees during the summer of 1926. The following is an account of our work.

Anthidium porteræ Cockerell syn. *maculifrons* of authors, not Smith.

Hungerford and Williams (6) state that two females of this bee were observed nesting in a bank of coarse, quartz sand near a colony of bembecid wasps. The down of the cells of the nest was thought to be derived from thistle (*Cirsium*) stems or from the inflorescence. The tunnel of one was 10 inches long.

Most of our study of this species has been done at Point East [1] and at Base Line Lake,[2] near Boulder, Colorado. The nests have been found both on hillsides and on level ground, usually in bare areas.

[1] A small hill rising above the plains, 3 miles east of Boulder.

[2] Six miles east of Boulder on the plains.

We attempted to observe whether or not *A. porteræ* digs her own nest or uses one already constructed by another insect. Individual females have been observed as long as 15 minutes at a time entering, spending a few seconds within, and then leaving various types of holes. At other times the bee merely looks in and leaves. We have never seen this or any other species of *Anthidium* digging in the ground.

Sharp (9) states that the species of *Anthidium* do not form burrows for themselves, but use suitable cavities formed by other insects in wood, deserted nests of other bees or empty snail shells.

As far as can be ascertained, no one has before observed an *Anthidium* bee to drive away another insect and take the nest, although it has been generally assumed that it uses the deserted nests of another insect, or a convenient cavity.

While observing a wasp, *Odynerus dorsalis* Fabr.,[1] building and provisioning a nest, *A. porteræ* was seen to drive away this wasp and appropriate the nest for her own. A few days previous to August 2, a female of this wasp[2] had been observed working and nesting. During the morning of August 2, I had been watching this wasp excavating and carrying out moist pellets of earth. Shortly after noon she had apparently finished the nest. The following notes were taken in the field near Base Line Lake between August 2 and 5, 1926 (h).[3]

2 : 50′. See *Odynerus* returning, flying and carrying large lepidopterous larva. She enters hole with it, staying but a minute within, then leaves.

3 : 17′ 05″. Back without larva. Flies in wide circles after which alights near hole, tapping edge with antennæ a few times. Enters. Backs out. Flies away. The hole is 5 mm. in diameter.

3 : 38′ 10″. Back with another larva which she takes within. Out, and flies away.

3 : 40′ 15″. *A. porteræ* is seen flying low along ground and entering holes nearby.

[1] Kindly determined by Mr. S. A. Rohwer.

[2] An account of the habits of this wasp given by C. H. Turner, in BIOL. BULL. *42*, 1922, p. 153–172, 6 figs.

[3] Initial (h) refers to notes of Hicks; (c) to those of Custer.

3 : 41′ 08″. She comes to hole of wasp nest. Enters and remains within.

3 : 43′ 33″. Bee still within. Wasp returns, alighting at edge. *A. porteræ* is near top of hole with jaws spread in a threatening manner, and head blocking the entrance. Wasp jumps at bee in hole, then flies away. Back and strikes at abdomen of bee as the bee backs out of hole. Bee and wasp leave, fighting. Wasp soon returns, alights near hole, tapping it with her antennæ. Enters and is pulling out one larva as *A. porteræ* returns. Bee strikes and tries to bite wasp with her mandibles, a number of times. The wasp flies with larva and drops it 10 inches from hole after which she flies away. Bee then goes inside. Wasp returns but pays no attention to larva which she dropped but comes to hole and looks in for a time. She then flies away. *A. porteræ* leaves.

3 : 54′ 01″. Bee enters hole.

3 : 56′ 52″. Goes away.

4 : 05′ 50″. Bee returns.

4 : 06′. Wasp returns. Tries to enter, jumps back and flies away.

4 : 07′ 02″. Bee flies away.

4 : 18′ 15″. *A. porteræ* enters. Believe carried something inside.

4 : 18′ 40″. Leaves.

4 : 20′ 55″. Bee returns, carrying a load of down.

4 : 21′ 05″. Flies away.

4 : 23′ 40″. Returns with load of down.

4 : 24′ 15″. Leaves.

4 : 26′ 29″. Returns with down.

4 : 27′. Leaves tunnel.

4 : 27′ 01″. Wasp returns. Looks in. Goes in and comes out almost at once. Flies a few inches away. Returns. Looks in. Goes in. Out and is ready to go in again when *A. porteræ* returns with load of down. She strikes wasp and both fly. The bee follows wasp fighting and striking her while in the air. The wasp circles back to the nest followed by bee, and tries to go into the hole. The bee repeatedly strikes wasp as latter tries to enter. *A. porteræ* drives her away, following her out of my view.

4 : 29′ 33″. Neither have come back.

4 : 31′. Wasp back. Looks in and flies away. Back again soon. Looks in. Goes in. Flies away in a circle. Back to nest. In. Out with some down in mandibles. In again and out with down in mandibles. Six more trips in and out with down. Then out dragging larva by head. Gets larva half out and puts back in at once as though she sees mistake. In and out with five more loads of down. Is now 4 : 35′. Comes out again with load of down at which time bee returns flying at wasp and hitting her a number of times. Bee then enters hole. Wasp is back very soon again. Enters hole in which bee is in but backs out at once. Follows an active four minutes in which the wasp repeatedly flies about hole, returns to it, looks in, flies away a few inches, back, etc. The bee is well up the tunnel blocking the entrance, during this period. The wasp flies away.

4 : 41′. *A. porteræ* is still in the hole but has gone down so that cannot see her.

4 : 42′ 55″. Bee out. Flies around and back into tunnel. Goes down into cell.

4 : 46′ 10″. Wasp flying rather high over nest but does not stop.

4 : 48′ 20″. *A. porteræ* out. Flies a few feet away and back carrying nothing.

4 : 53′ 20″. Repeats above.

4 : 55′ 20″. Repeats.

4 : 57′. Bee backs out dragging larva carried in by wasp to the outside. Drops 2 inches from nest. Enters. Out head first. Leaves.

5 : 01′ 02″. Back with down.

From this time until 6 : 30 the bee carried 17 loads of down. The wasp was not seen again. The next day the bee carried 18 loads of down. The day was partly cloudy. On August 4, by 10 o'clock the bee was collecting pollen and by 9 : 15 A.M., August 5, the nest was complete with the tunnel filled with pebbles to the surface of the earth (h).

Anthidium bees have been observed by many students to use down from various plants growing in the vicinity of the nests. Fabre (2) found that some would even readily make use of that from introduced plants. He states that *A. diadema* will take the cotton for its work from any suitable plant growing near its nest. This bee nests in hollow reeds placing as many as ten cells in one stem. The most we have found here have been two in one nest, more usually one. This is due to the fact that most of ours have probably taken over wasp nests providing space for but one or two cells.

According to Friese (3) certain European *Anthidia* obtain their down from the leaves of different hairy plants, among which are especially such plants as *Stachys*, *Ballota*, *Cydonia*, *Verbascum*, *Populus* and *Gnaphalium*.

A. porteræ gathers down from the underside of the leaf of *Cryptanthe gracilis* Osterh.,[1] by scraping it up towards the apex with her mandibles.

After visiting several leaves she then holds the ball gathered with the mandibles between the thorax and front legs and flies with it thus to the nest. A given individual usually returns to the same group of plants to obtain the down. One bee averages two and one-half minutes in securing a load (c).

We have observed a bee to go a distance of over 50 yards in securing the down although some others have been seen to go but 5 yards away while one at White Rocks went but 3 feet from the nest.

In August, 1926, *A. porteræ* was observed to gather down from the stems of live *Artemisia canadensis* Michx.[1] One female was observed while she went from plant to plant visiting a large number on one collecting trip. This bee scraped the down in much the same manner as those observed working on *Cryptanthe*. It would seem that this latter plant is much better for the bee as it has more down and requires less work to obtain it (h).

On July 20 and 21, 1926, notes were taken on the provisioning of a cell, an extraction of which follows (h).

One nest was watched continuously for a number of hours. The opening to the tunnel was slightly enlarged so that the bee could be seen working within. She would return to the nest carrying the down with her mandibles, enter, and arrange it

[1] Kindly identified by Dr. Edna Johnson.

into a cell shaped for the reception of the pollen. She usually turned herself around once and sometimes two or even three times in the placing and working of each load.

In returning to the nest the bee came direct, leaving in the same manner. Although the weather was partially cloudy the bee carried 26 loads of down in two days, an average of six minutes and thirty-eight seconds for each load.

The time of individual trips varied from 4′ 49″ to 16′ 05″. The time spent within the nest, arranging the down varied from 1′ 10″ to 2′ 20″. The time taken to get the down is determined by weather conditions, distance secured from nest, time of day, etc.

At the time of provisioning, the cell had an inner cavity, a little larger than the bee. She began at 1 : 40 to carry pollen and between this time and 3 : 30 carried 6 loads. The time spent within the nest averaged about 2 minutes. On arriving, the bee opened the top of the cell, entered head first, came out, and backed in, forcing the abdomen inside. While here, she removed pollen from the ventral scopa and deposited it in the bottom of the cell. Before leaving the nest, she always partially closed the cell by raking the down together at the orifice. This may make it more difficult for parasites to find or enter the nest.

After depositing the pollen, the bee was not seen to enter the cell again until she had returned from another collecting trip. If nectar was deposited after each collecting trip, it of necessity was deposited first when the bee had her head within. However, the first pollen was seen to be dry and it was not learned if separate trips were made to gather nectar or not. The final food for the young is very moist (h).

After provisioning, laying the egg and closing the cell the bee fills up the tunnel, usually with pebbles. These may be selected from a small area over 9 yards from the nest, in rare instances, but more usually from 1 to 3 yards away. A number of times the bee has availed herself of the pebbles of a large red ant nest (*Pogonomyrmex occidentalis* Cresson).[1] The number of pebbles used is at least enough to fill the tunnel above the cell even with the surface of the ground. The size of the tunnel and the

[1] Kindly determined by Professor T. D. A. Cockerell.

distance above the cell varies. From 135 to 300 pebbles are used, 250 being about the average.

Sometimes a bee loses its hold or attempts to carry a pebble too heavy and is forced to drop it. She then goes at once to the place, from which she secured the one dropped, for another. However in one instance, upon dropping the pebble midway to the nest, the bee alighted at the spot, seized another, and continued on her way. The bee usually drops the pebble from above the hole into the tunnel but on a few occasions she was observed to alight on the edge before dropping it in. Sometimes the pebble fails to hit the hole and remains close to the edge. While filling the hole the bee frequently enters to arrange the pebbles. In doing this she turns them with her mandibles and fits them into position snugly. In only one instance, after the bee had gone inside to arrange the pebbles, have we observed her on leaving to rake in some pebbles and soil from near the edge with her mandibles and fore legs.

On July 24, 1926, found bee filling tunnel. She was watched until the end of this period. The following is an extract from more detailed notes taken in the field (h).

At 8:50 A.M. found *A. porteræ* entering hole in ground with piece of dry dirt. The hole was large enough to see inside and it was noted that only a few pieces had been deposited for the down was not covered. When first observed the bee was carrying material from a place 12 feet east of nest. She carried 10 loads in an average time of 12 seconds. Each time the bee alighted on the ground and selected the piece of dirt. These chunks varied somewhat although the average was quite uniform.

After she carried a few more, a circle of stones was placed about the nest while she was after a load. The stones were about the size of a hen's egg and were 3 inches from hole. On returning she circled 3 times about the hole, then flew 10 feet away, returned, alighted on ground, returned and entered hole. She then went to collect again and continued, returning direct and without further hesitation, paying no more attention to the change. After 15 more loads she changed her place of selecting materials to 18 feet south of nest. The bee, after every few loads, went and arranged them. After 56th trip changed back to position

12 feet east. After 113th trip (9:47) bee went to feed on *Psoralea* plant. She was followed and was found to visit 83 flowers in 6 minutes. She then carried 3 loads into nest and fed again, visiting 15 more. The 139th trip ended at 10 o'clock.

The bee had no sooner alighted, after the 155th trip than a male met her. The period of mating lasted 25 seconds after which the female went on with her work as before. In one instance she carried in a piece of old stem which was so long that it was bent back to get into the hole.

She made in all 240 trips between 8:50 and 10:26 at which time the tunnel was filled even with the surface. This bee carried in almost entirely pieces of dried mud; all others observed have used mainly pebbles. The nest was dug up and consisted of two cells. This nest was of the nature of those made by *Odynerus dorsalis* Fabr. The lower cell was opened and contained a small larva of *A. porteræ* which later died. The upper was not opened until in September at which time a cocoon had been formed containing a live, mature larva. In this instance one mating took place after the egg of the two cells had been laid, both eggs hatching. It is probable that *A. porteræ* mates more than once. Other matings have been observed to take place while the female was collecting pollen for the cell. Once a female of this species was found to be mating with a male, *A. porteræ amabile* Ckll., a variety with more red on the abdomen (h).

The mass of pollen, semi-fluid in consistency, of the cell of *A. porteræ* is 10 mm. long, flat on the top surface and curved on the base. The egg lies flat on top of the mass of provision. A larva $2\frac{1}{2}$ mm. in length was found to be partially embedded in the food. The exact larval period has not been ascertained although a number of cocoons have been formed in the laboratory. The larvæ of those opened never developed much further and it was thought that this might be due to the pollen drying out as well as to possible mechanical injury (h).

The size of the entire cell including the down varies a little, due to the size of hole in which the down is placed. One which was about average in size measured 17 mm. in length, being 12 mm. wide at the bottom and 10 mm. wide at the top. Pellets of excrement mixed with down were all about the down and between the cocoon and the outside (h).

The outer surface of the cocoon has a thin layer of rather light, loosely woven silk. Removing this the denser, darker cocoon is found. An average cocoon measured 10 mm. in length and 5 mm. wide, being oval in shape with the ends somewhat flattened. The anterior end bears a mammillary point which externally contains an opening. This point is not so long nor so conspicuous as the one on the cocoon of *Dianthidium sayi*. One large cocoon measured 12 mm. in length and 7 mm. in width. The cocoons found have been reddish brown. One of the cocoons described, held to a bright light showed the outline of the larva within (h).

We made certain investigations in which we attempted to find if *A. porteræ* would carry pebbles indefinitely to the nest. While the bee was away for a few seconds to obtain another pebble we removed the one, with a pair of forceps, she had last dropped in. Thus the nest was kept continuously empty or partially so.

On July 27, 1926, at Point East at 3:15 P.M. we found a bee carrying large pebbles from the nest of the red ant (*Pogonomyrmex occidentalis* Cress.) 9 yards away. The nest at that time was about half full. We removed 175 pebbles by 5:20 P.M. when the bee quit working for the day. The nest was watched until 7:00 P.M. and from 7:15 A.M. the following morning but the bee was not there at either time and no pebbles had been carried in the interval. She started again to carry pebbles at 7:55 (July 28). From 7:55 to 8:20 she carried 100 stones, which is an average of 4 stones a minute. Later in the day (10:00 A.M.) she was found to be averaging 8 a minute, probably due to the increased intensity and heat of the sunlight. She carried 311 pebbles before noon, having fed early in the morning, suddenly stopped and was seen no more. Although the nest was watched for days, no more pebbles were carried. The total number carried was 741. The bee was not frightened away and apparently quit voluntarily, leaving a number of pebbles in the nest.

To another nest a bee carried at least 400 pebbles and suddenly left, although the hole was kept partly empty as in the other case. Before stopping, in each instance, there was no apparent slowing down of the work, nor cloudy or cool weather. The bee stopped during weather conditions very favorable for work.

In two instances, I have found the nests of some species of *Anthidium* in which the tunnel was unusually short, and over and above which she had carried a mound of pebbles instead of just filling even with the surface, as in the case of nests having longer tunnels. In one instance 135 pebbles and in the other 75 had been carried, more than enough to fill the tunnel (h).

From our investigations it would seem that *A. porteræ* will not carry pebbles indefinitely even under ideal weather conditions.

Whenever the cell becomes damp and mold develops, as sometimes after rain, the nest is deserted.

Both males and females have been found resting in the dry pods of yucca stems during rainy or cloudy weather, in cavities in decayed wood or resting, perched bird-fashion on stems during the night.

During the day when the weather is fine the males dart from flower to flower and are often seen hovering humming-bird fashion in the air. Part of the day is spent in feeding and part in searching for the female. He often darts upon the female while she is working, copulation taking place on the ground. The duration of this period is about 30 seconds. As yet we have reared no parasites.

Summary.

1. No females of *Anthidium porteræ* have ever been found digging a nest.

2. On one occasion she drove away a nesting wasp, *Odynerus dorsalis*, and used the nest for her own.

3. The nests found in which the cells of the bee are placed have in general been such as are made by wasps or other insects nesting at the time.

4. *Anthidium porteræ* is solitary and is not found nesting in close association as *Dianthidium sayi* and others.

5. The cell is constructed of down and the tunnel above filled to the surface of the ground, usually with pebbles.

6. When the stones are removed artificially from the tunnel, *Anthidium porteræ* probably will not replace them indefinitely even under ideal weather conditions.

Dianthidium sayi Cockerell syn. *interruptum* Say. (nom. preocc.).

The bees of the genus *Dianthidium* have been known to construct nests of resin on rocks, in stems of plants, in deserted snail shells and other places, but, so far as we know, seldom in the ground as does *Dianthidium sayi*. We have found no reference to the nesting habits of this species except that in 1926 by Hicks (5). This latter information was derived from a number of cells dug up from a small area at White Rocks, during fall of 1925 near Boulder, Colorado. We have obtained our field notes during the summer of 1926 mainly at this locality where two colonies, one hundred yards apart, were found and studied.

The six colonies of *D. sayi*, observed during the latter part of the summers of 1925 and 1926, were all located on hillsides that face south and slightly east. Scattered over these hillsides were tufts of *Bromus brizæformis* Fisch. and Mey.,[1] to the roots of which some of the resin cells were attached. We find that the species may nest as a colony of from eight to fifty or more females, although one apparently solitary female was found nesting in a vertical clay bank. The colony is at its maximum activity during the month of September.

The picture shows a small colony of *D. sayi* on a grass-covered mound of sandy soil one yard in diameter. Base rock surrounds this on all sides, the nearest soil being five feet away. Tall

[1] Kindly determined by Dr. Francis Ramaley.

stems of *Bouteloua oligostachya* (Nutt.) Torr. and *Bromus brizæformis* Fisch. and Mey., rise a foot or so above the colony; thus chaff, small sticks, etc., are abundant. The nests were marked, as seen in the picture, 1 to 16 by small numbered strips of paper securely weighted with sand. Nest 7 has been plugged up. The picture shows bee *H*, whose thorax is white for identification, very near and to the left of this nest. She is standing on her hind legs with the fore legs on the bank just above the nest. Nest 4, hidden from view, is a foot behind 2 while nest 14 is a quarter inch above 5. Nests 11, 12, 13, 15 and 16 are hidden from view in the grass to the left of 14. Nests 7 and 8 are about twenty-five inches apart (c).

All bees concerning which notes were taken were marked with waterproof white paint. Thus the thorax of the bee seen beside label 7 is white. Bee *C*, on whose habits many important notes were taken, was marked as follows: (1) Left half of dorsal surface of last abdominal segment white; (2) A black area present on left side of fourth dorsal abdominal plate completely surrounded by a yellow tegumentary band which area, on right side of same abdominal segment, was not completely surrounded; (3) Right postero-lateral quarter of mesothorax dusty, probably due to some resin sticking there at one time and dust adhering to this (c).

One bee was seen to have two nests in the process of construction at which she worked more or less alternately. Later, five such bees were observed. These were shown to and verified by Hicks. The following short extract illustrates this habit in the case of one bee: Bee *C* is constructing two nests which are nine inches apart. Into one nest she carries pebbles, lumps of dirt, chaff and such sticks as she can handle with her mandibles. Then she flies directly to the other nest and does the same thing there. Thus she carries the following number of these articles

To Nest 1:	Then to Nest 2:
6	6
4	5
9	0

(Then a male arrives and they mate while she has a stick in her mandibles (60 seconds). He leaves and she continues her work after carrying this stick to nest 1.)

23	0

(She flies to flowers of *Grindelia* several yards away, and feeds there for ten minutes; then she returns to work as before.)

5	1
5	0

Here she flies to the fields. One of the sticks is one and one half inches long (c).

The following account shows this habit in another individual: Bee *D* goes into nest 3 for fifty-five seconds. After going out and in several times, she leaves, flies slowly over to nest 4, nine inches away, and goes in at once. Presently she leaves this nest and flies to some nearby flowers to feed. In one minute she arrives at nest 3, leaves after a few seconds, and flies slowly over to nest 4 which she enters. After one half minute, she leaves, feeds for five minutes and goes into nest 3. She comes out, three quarters of a minute later, goes into 4 and spends one half minute there before leaving for the fields to feed (c).

It has not been observed whether or not *D. sayi* digs the hole for its nest and so it can not be proved that one bee has attended to two holes from the first. However, the proximity of the nests to one another indicates that it does the former. It might easily be that each summer, when the colony began to nest, there was but one bee to each hole. Then when some of the builders died, before completing their nests, others of the colony would appropriate these deserted nests and finish them along with their own. The following examples are taken from the notes to give evidence that temporarily deserted nests of *D. sayi* are readily taken over by other members of the colony:

Example 1.

Sept. 14, 1926. While bee *I*, the owner of nest 8, is in the field, another member of the colony comes and goes into the nest. Thirty-five seconds later, bee *I* arrives and goes into nest 8 also. Presently the owner backs out and is followed closely by the intruder. The former alights on the intruder's thorax, biting with the mandibles at the junction of head and thorax. A short, lively tussle follows, after which the intruder escapes and the owner goes on working.

Example 2.

Sept. 17, 1926. Bee *D*, which has been constructing nests 3 and 4, has now spent ten minutes carrying chaff, etc., into 4. In the meantime, bee *I*, which has been working on nest 8, arrives from one of her numerous trips to the field and goes into nest 3. She at first makes regular trips carrying soil out of this nest. Then she seems to be carrying pollen in. The owner of nest 8 has been working on 3 all day and has but rarely visited 8. The owner of nests 3 and 4 has continued to carry chaff, etc., solely into 4, eventually plugging it up. The next day the owner of nest 3 returns. The owner of nest 8 sees her return and so is now working as before on 8 (c).

Five bees by this time (Sept. 17) have been seen repeatedly to visit two nests apiece. To summarize, they are: (1) Bee *C* to nests 1 and 2; (2) Bee *D* to nests 3 and 4; (3) Bee *E* to nests 5 and 14. (4) Bee *I* to nests 8 and 3 (to 3 only to-day); (5) Bee *H* to nests 6 and 7. There are eight bees working in the colony. Of the sixteen nests, nine are open and seven are plugged, but of the latter, numbers 7, 15 and 16 are not being worked upon by the bees. Thus the eight bees of the colony are working on thirteen nests, and three of these bees are seen to work on but one nest apiece (c).

On September 26, we dug up the colony and found 151 completed cells from the 16 nests, which is an average of 9.44 cells to a nest. This was practically the end of the nesting season, for at this time and later the colonies of *D. sayi* were deserted.

It is interesting to note, from a standpoint of comparative entomology, that a wasp, *Sphex varipes* (Cress.)[1] has been observed to be taking care of two nests also (h).

From these facts and others in our study of bees, we have found that there is sometimes considerable variation in the habits of different individuals of a given species.

[1] Kindly determined by Mr. S. A. Rohwer.

The picture shows bee *H* in one of her numerous visits to the plugged hole 7. Her action suggests that a bee retains the memory of her nest for at least a week after it has been completely plugged up and that her visits are made to it to insure its security from enemies. A brief extraction from my field notes illustrates her action: "Bee *H* goes into nest 6 for one and one half minutes, comes out and goes over to plugged hole 7. She spends about ten seconds here. Upon arriving at 7, she first puts her head down against the plug, rubs it with face and mandibles and scratches weakly with fore legs for three or four seconds. She then stands erect before the nest on her hind legs with her fore legs against the bank above the plugged hole (see picture). After standing thus motionless for about five seconds, she flies away to the fields. She repeats this procedure many times daily in like manner. Only occasionally does she first go to nest 7 and then to 6" (c).

While bringing out soil from within the nest, after the tunnel has been constructed, bee *D* has been observed to back out, raking it with her forelegs. She usually leaves this within an inch of the entrance although in a few instances she took it out in this manner as far as six inches, and once ten inches (c).

D. sayi obtains the resin used in the construction of the nest from the small sunflower, *Helianthus petiolaris*. She obtains this resin, with her mandibles, from the stem and partially or totally dried leaves which have small droplets and plates of it distributed over them (c).

Fabre (2) studied "resin workers" for many years but states that he never saw a bee get resin. Friese (3) states, in reference to the source of resin used by a species found in Europe, that it is probably obtained from the buds of the pine. Hacker (4) inferred that *Megachile rhodura* used resin for its nest since he observed members of both sexes visiting a *Eucalyptus* tree, from which resin had oozed, and rasping the resin with their mandibles. However, he did not find *M. rhodura* nesting. Melander (7) presumes that the resin used by *Anthidium texanum* Cresson was obtained from cedar. Hungerford and Williams (6) say, in their account of *Dianthidium concinnum* (?) Cresson: "The nest of this insect is composed of pebbles glued together with resinous cement which may be derived from the stems of *Helianthus* which are often infested with a small lepidopterous borer that causes an exudation which usually attracts a host of Hymenoptera."

The following field notes were taken, giving the resin activities of bee *C* during one hour:

12:57½. Arrives with resin in mandibles at nest 2. Kneads resin with mandibles.

1:00. Obtains a piece of chaff an inch away from nest and inserts it into the resin which by now she has shaped into a plug over the ends of the pieces of chaff projecting from the burrow.

1:06¾. Carries piece of chaff to nest 2.

1:07. Obtains small stick and flies with it to nest 1.

1:07½. Flies away. I follow her. She goes to some flowers of *Grindelia* and feeds.

1:09½. Flies to some dried plants of *Helianthus petiolaris*. Picks a plant without many red and black ants present and scrapes resin off with mandibles. She visits three plants.

1:12¾. Arrives from fields at nest 2. Has in her mandibles a load of resin about one fourth as large as head. Distributes resin over ends of chaff projecting from the entrance.

1:21. Flies to nest 1.

1:21½. Leaves nest 1. Goes directly to sunflower plants and secures resin.

1:24. Arrives at nest 2.

1:25½. Leaves nest 2.

1:30. Arrives and leaves after two seconds. I follow her to several flowers of *Grindelia* where she feeds.

1:32. Arrives at nest 2 and leaves, after two seconds, for the fields.

1:34½. Arrives at nest 1 with white resin in mandibles. Works here with the resin in the construction of a plug.

1:36¾. Obtains large pebble two inches away and inserts it into resin of nest 1.

1:38. Flies to nest 2 and works with plug there.

1:42. Carries stick to plug at nest 2.

1:42½. Leaves nest 2 and feeds at flowers of *Grindelia* and of *Helianthus petiolaris*.

1:46. Arrives at nest 2. Leaves after two seconds and again feeds.

1:48. Arrives at nest 2. Walks all over colony looking into several nests and returns to this one.

1:49. Flies away.

1:51. Arrives with resin at nest 2.

1:51½. Obtains piece of chaff and takes to nest 1. Gets stick midway between nests 1 and 2 and carries it to nest 2.

2:01. Leaves nest 2 and obtains resin after feeding on flowers of *Grindelia*, etc. (c).

The entrance to the tunnel, after the completion of the cells, is closed by a plug of resin, chaff and other materials. From several plugs taken out, we find that the resinous part is about 2 mm. thick. Usually, in constructing the plug, the bee first places a few pieces of chaff, sticks, etc., in the entrance and then builds a resin cap over the projecting ends. Beyond the plug, towards the cells, the tunnel is often empty and may be coated with resin.

One of us (Hicks) (5) has described the cells of *D. sayi*. Last summer it was not known whether all the materials found in the resin had been carried there by the bee or were there by chance. Observations this summer show that she obtains the chaff, sticks, etc., which are found mixed with this resin, from the vicinity of the nest. In some instances she has been found to carry fifty or more pieces of chaff, etc., into one tunnel until it was filled. After this she finished the nest with a resin plug. The resin cells are often found attached to the grass roots in similar fashion to peanuts on the stem.

D. sayi varies considerably in the distance which she carries the stones, dried mud, etc., with which she constructs the nest. Bee *J* (attending to nest 9) is seen to make many trips with plates of dried mud from an old mud puddle, six yards away, to her nest. Bee *E* (attending to nests 5 and 14) is seen to carry many large pebbles to her nest from a sand pile eleven yards away. She places these in nest 14 after having plugged up 5 (c).

D. sayi may also obtain chaff and sticks from a distance varying from three inches to three yards away. One individual selected material near the nest but did not repeatedly obtain it from the same place; another repeatedly visited a more distant source. This latter was usually found to reject several pieces of chaff, etc., before taking one to the nest (h).

The female of this species (bee *C*) was seen to mate twice within three days. The first mating, on September 13, is recorded in field-notes given on page 270. The second mating is given in the following extraction: On September 16, bee *C* leaves nest 1, which is now almost totally plugged up with chaff, etc., and flies to some flowers of *Grindelia* to feed. She then flies to some small sunflowers nearby and feeds there also. Finally she goes to a flower of *Lygodesmia juncea*. While feeding there, a male arrives and they mate. This mating takes sixty-five seconds. The female is grasping the stamens of the flower with the fore and mid legs and is touching the hind legs repeatedly on those of the male. This is apparently the first record of a wild bee mating more than once (c).

The male has been observed to await at the colony the return of a female. As soon as she arrives, he darts at her to effect copulation and in some cases they collide in mid-air, both falling to the ground. The female, with partially outstretched wings, rests motionless except for a slight movement of the hind legs on those of the male. The male has the female grasped around the third abdominal segment with the forelegs and beneath the abdomen with mid and hind legs while the tips of his antennæ are bent forwards and outwards. His only movement is a relaxation and contraction of the abdominal segments and a slight waving of the tips of the antennæ. The average time for copulation, from seven examples, is very close to a minute (59.7 sec.). We have observed that mating may occur both at the colony and at the flower while the female is feeding. Although the male is absent from the colony most of the time, nevertheless the majority of the matings observed have taken place at the nest.

Mating probably does not interfere with the nest-building activities as evidenced by the field notes on the first mating of bee *C*. Furthermore, a female has been seen, returning laden with pollen, to mate, after which she immediately went into the cell, deposited the pollen and went on with her work.

D. sayi has been observed to feed on the flowers of the following plants:

(1) *Grindelia squarrosa.*
(2) *Helianthus petiolaris.*[1]
(3) *Sideranthus spinulosus.*[1]
(4) *Lygodesmia juncea.*[1]

After a rain, which partially filled the entrances of some holes, we completed the closing of these with wet sand to observe the later action of the owners. One, entrapped within the nest, used the mandibles to remove the plug; another, returning from the fields, also used her mandibles to gain entrance. The latter was observed to place head and mandibles into a small excavation, which she had formed, and to walk in a clockwise direction around the hole with the tip of the abdomen describing a circle. The forelegs were practically useless in this process. The abdomen was not used in this case to pack the soil in repairing the walls, as has been observed in a bee of the genus *Augochlora* under similar circumstances.

D. sayi has not been found feeding beyond a radius of one hundred yards from the nest. However, of six marked females released four hundred and fifty-five yards from the colony, four returned within five hours. The shortest time required to return this distance was twenty-one minutes. Two specimens released one hundred yards from the nest returned shortly, the first within fifteen minutes, after feeding along the way (c).

The only parasite of *D. sayi* which has been bred is a fly of the genus *Villa* (Anthrax),[1] Hicks (5). Some mutillids and chrysids may be parasitic since they have been frequently observed to enter the open or partially plugged-up nests.

Summary.

1. Several instances of a female bee, *Dianthidium sayi*, working alternately on two nests in the process of construction, have been found. This has also been observed in a species of wasp, *Sphex varipes*. Apparently these are the first records of this habit.

[1] Determined by Professor T. D. A. Cockerell.

2. Resin, used in the construction of the nest, is obtained from the leaves and stem of the small sunflower, *Helianthus petiolaris*.

3. *D. sayi* is one of those wild bees whose members nest in close association with one another.

4. A female of this species was seen to mate more than once.

5. *D. sayi* seems to be nearly free from parasitism.

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